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An Efficient Dynamic Route Optimization Algorithm for Mobile Ad hoc Networks

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Abstract

In mobile Ad hoc networks, topology changes caused by mobile nodes may lead to the occurrence of link failure and redundant links. The link failure issue can be solved by insert relay nodes, but the latter question is not settled well. This paper presents a dynamic route optimization algorithm DROA which can effectively continue to optimize the path. With the topology changes, the algorithm chooses the optimal route to update the transmission path periodically, thereby reducing the number of hops and delay, avoiding restart the route discovery, saving control traffic and energy cost. The NS2 simulation platform is chosen to verify the performance of our algorithm. Experimental results show that in comparison with AODV, DROA has a better performance in end-to-end delay, path length and route life without more energy consumption.

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*Keywords:*On demand;mobile node;path length;redundancy; dynamic route optimization

1.Introduction

Wireless network routing technology has been studied for many years. Researchers have proposed various routing protocols to adapt different network framework and application scenarios. One of the most difficult problems in route algorithm of mobile Ad hoc network is how to keep the performance while the nodes move. Mobility will lead to dynamic changes in network topology, which makes the design of routing algorithm very difficult. The moving of the node may lead up to disconnection of the link, which increases the complexity of routing maintenance. Passive routing protocols such as AODV [1] usually deal with the problem of link failure or disconnect through local route repair or route discovery. Some literature employed methods by insert relay nodes to resolve this issue [2-5].

However, the mobile node may also bring about redundant nodes owing to lack of routing update. In AODV protocol, when the source node needs to transmit data, it establishes a route to the destination. In the connection establishment phase, AODV chooses the route based on the principle of the first the

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“best”(fastest) to build the approximate minimum hop route. With the passing of time, if a certain link failure, it needs to restart the route discovery process. If the topology change, but the links maintain stable, then the path length of the connection may become much longer than the shortest path. Fig.1 shows the formation of redundant nodes and paths.

Park and Voorst et al. proposed “Anticipated route maintenance” method [2, 3], which use GPS device to get node locations and velocities to predict the link failure between

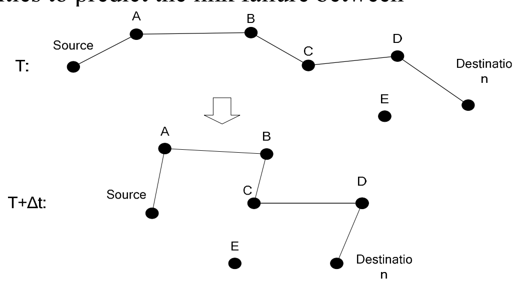

Figure 1. Formation of a non-optimal route

nodes within a time slice. The algorithm is divided into two phases: Expand and Shrink. In the Expand phase, the algorithm will insert bridge nodes into a weak link to avoid route fail; and in the Shrink phase, the algorithm eliminates the redundant nodes on the path to shorten the route length. However, in the course of Shrink it needs to exchange routing table information, which will generate a large number of traffic overhead.

Qin et al. [4] proposed a method to predict the link status based on continuous received signal strength. When a node finds the adjacent link may fail, it sends a message to request the source node re-select an alternative relay. The proposed mechanism tries to find a backup route before disconnect, which can reduce the packet loss by predict link failure but still need to activate the route discovery process.

The algorithm in [5] is similar to Park and Voorst’s GPS-based solution, the location information is used to detecting unsafe links, which refers to these links that the distance between nodes longer than the specified threshold value. When found an unsafe link, the local broadcasting is performed to find a suitable relay node between endpoints of the unsafe link. Similar to the method of Park et al, it is also a path expanding mechanism. But [5] didn’t present shrink operations, so their approach may still result in redundant nodes.

Bilgin et al. in [6] proposed "Shrink" mechanism to dynamically optimize the routing. The difference from [4] is that it does not need to restart the route discovery, but active the Shrink Mechanism in accordance with a certain probability by sending a message to detect whether there is redundancy in routing path and optimal path through the RSS. The key point of the mechanism is to eliminate redundant relay nodes and reduce a 2-hop connection to 1-hop connection. It make up the deficiency of these schemes previously mentioned, which reduces the number of redundant nodes and optimize the route. Besides, it doesn’t need to exchange routing tables. However, the mechanism is limited to shrink 2 hops on the same route, so there is still much room for improvement.

Based on the analysis of these studies, the expand mechanism can resolve the link broken caused by node moving, but these studies is still lacking on reduce the redundant links and nodes. Therefore, in this paper we propose an improved routing algorithm DROA which can choose the optimization path dynamically, reduce delay and the number of forward times. As the topology changes, it dynamically maintain the path approximate shortest.

2.Dynamic route optimization argrithem

The dynamic routing algorithm DROA proposed in this paper puts forward the periodic optimization mechanism to shrink the path, deletes redundant nodes, and reduces the number of relay packets and decreases forwarding delay. In addition, the probability of route discovery re-initialization is also decreased. The mechanism performs only if the route in active status.

2.1.Message Type

DROA		
-Packet_Type		
S-0	S-1	S-2
-Hopcount -Source -Src-seqno -Destination -PrevHop -NextHop -TTL	-Hopcount -Source -Destination -PrevHop -NextHop -TTL	-Hopcount -Source -Src-seqno -Destination -TTL

Figure 2. Packet structure.

There are three new message types in DROA: S-0, S-1 and S-2. The packet format is shown in Fig.2. S-0 is broadcasted to downstream nodes in order to optimize the follow-up path persistently. The hopcount field represents the distance to the destination. The source and source sequence are used to update the route, which have the same meaning in AODV. S-1 is a response to S-0, and S-2 is used to notify the downstream nodes to update the reverse path.

2.2.Initialization

Source node periodically initializes the shrink process for each connection until the connection is finished. The Initialize process can perform according to fixed time period or certain probability. In this paper, we take the random probability of trigger mechanism the same to [6], in which the source node sends packet each time when the shrink starts in accordance with the probability factor P.

Suppose the source node S has already established a route to the destination node T, and S send data packets to the destination node at a constant bit rate F frames/second. The optimization algorithm is initialized by the source node S. When S needs to send a data packet, it will generate a special type packet S-0 according to the probability P, whose TTL is set to 1. The Source node S broadcasts the S-0 packet to all of the 1-hop neighbor nodes.

2.3.Update the route

Once receive the S-0 message, the node compares the hopcount of it and the sender to judge if it has the shorter path to the destination. If the node owns a shorter path, then it unicast S-1 message just 1-hop to notify the sender of S-0, and update the reverse route. Otherwise, it will drop the message. Besides, if the node is on the route, it will rebroadcast S-0 message downstream to continuous optimize the follow-up path.

The node who receives S-1 will decide if there is really a better path. If true, it will update the next hop to the sender of S-1, and delete the redundant relay nodes and unicast the S-2 message to the destination to notify the downstream nodes to update the reverse path. Due to the instability of links, we can also verify the link availability by RSSI. This process is illustrated in Figure 3.

By this way, the algorithm can shorten the path more than 2-hops, either on the same route or not. As show in Fig.3 (a), if node F has the shorter path to the same destination T, then the upstream node A change the path to F. The Fig.3 (b) shows the algorithm shrinks 2 nodes (B, C) on the same route.

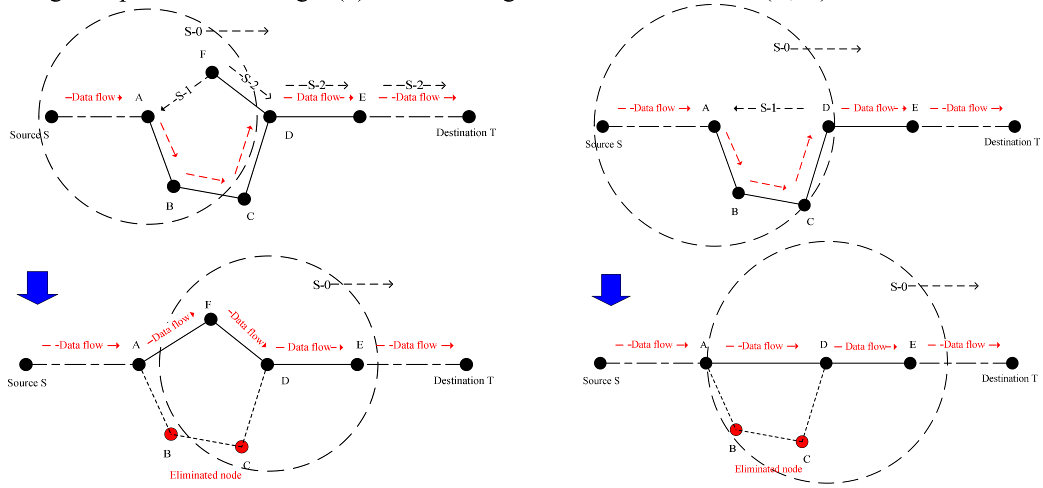

Figure 3. The Dynamic Route Optimization Argrithem: (a)the relay not on the route (b)the relay on the same route

This process can be described by the following pseudo code:

```
IF packet_type eq S-0
    IF Lookup(Destination) eq TRUE
        IF S-0->next_hop eq local_address
            Broadcast(S-0, TTL=1);
        ELSE IF Lookup(Source) eq
            IF |S-0->hopcount - local_hopcount| ge 2
                Unicast(S-1, prevnode, TTL=1);
                Update_route(Source,);
                Broadcast(S-0,TTL=1);
        ELSE
            IF |S-0->hopcount - local_hopcount| ge 2
                Unicast(S-1, prevnode, TTL=1);
                Update_route(Source);
                Forward(S-2, nexthop, TTL=30);
    ELSE Free(Packet);
IF packet_type eq S-1
    IF |local_hopcount - S-1->hopcount| ge 2
        Update_route(Destination);
    ELSE Free(Packet);
IF packet_type eq S-2
    Update_route(Source,seqno,nexthop);
    Forward(S-2, nexthop, TTL= 30);
```

Figure 4. Pseudocode of the DROA.

The above briefly describe the principle and implementation of DROA on a single connection. In fact, the whole network may consist of a number of different routes or connections. For the mechanism on each route is mutual independence, they will not affect each other.

3.Performance evaluation

3.1. Simulation Environment

Table I.Parameters of the simulation

Parameter	**Value**
Network Size	1500m×300m
Number of Nodes	50
Deployment	Random Deployment
MAC	802.11
Antenna Model	Omni Antenna
Radio Propagation Model	TwoRayGround
Transmission Range	250m
Mobility Model	Random Way Point
Move Speed	0-10m/s
Traffic Flow	CBR
Max Connection	20
Packet Length	512Byte
Simulation Time	300s

The route algorithm we proposed is implemented in NS2.34. We compared it with AODV in different performance metrics.

The simulation network consists of 50 nodes that are randomly deployed in a 1500×300m2 rectangular region. The simulation time is 300 seconds. The random waypoint mobility model was adapted, and the nodes move randomly in the deployment area at the speed between 0 and 10m/s. After moving to a random target position, there is a pause time before the node starts a new movement. If the pause time is set to 0, the nodes move continuously; and if the pause time is equal to the simulation time, that means the nodes will remain at rest. The main parameters of the simulation are shown in table I.

3.2.Simulation Result

Following is the list of the used performance metrics:

- Average residual energy: compute the average residual energy through the NS2 energy model, then make a comparison of DROA and AODV.
- Average path length: reflect the path optimization effect. The path length can be indicate by the routing hops, we compare it with the minimum number of hops (shortest path) to obtain the normalized path length.
- Average routing delay: the delay of the packets send from the source to the destination, indicate the ability of real-time communication.
- Average routing life: the average time interval of the route broken, which show the stability of the routing.

We compare the performance of DROA with AODV under different condition and obtain the simulation results.

Fig.5 shows the contrast of the average node energy in different time of the simulation. While the source node produce a certain amount of data according to the probability of starting in DROA, the experimental results show that the average residual energy of DROA is slightly lower than that of AODV. Because the DROA optimize the path length and reduce the packet forwarding time, so the energy consumption increased but not significantly.

Fig.6 shows the comparison of the normalized average path length. Under different pause time, the average path length is shorter than the AODV. The path length of DROA is much closer to the shortest routing path length, and the more frequently the nodes move, the more obvious effects. As the pause time is 0, the normalized average routing length of DROA is 1.1, while AODV 1.22.

Fig.7 is the comparison of average route delay under different pause time. The average routing delay of DROA is significantly lower than AODV, which is inevitable after optimization. In addition, with the mobility of nodes increase, the delay of DROA significantly reduced. By contrast, when the frequency of moving become slower or stop moving, it closer to the average delay of AODV.

Fig.8 is a comparison of the average route lifetime, reflecting the stability of routing. The more frequent of the node move, the more effective of the algorithm. But if the mobility of network decreases or even remains at rest, the average life approaches the AODV routing's

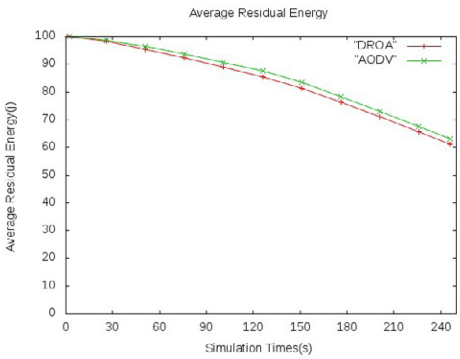

Figure5.Average Residual Energy

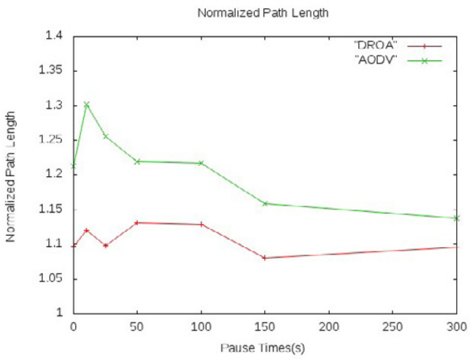

Figure6.Nomalized Path Length

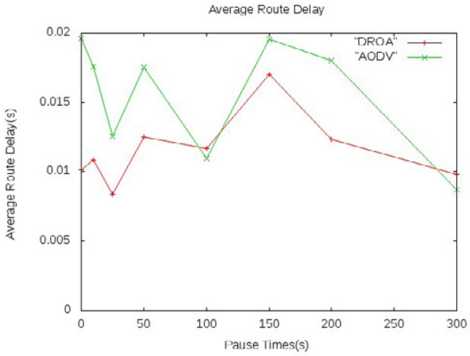

Figure7.Average Route Delay

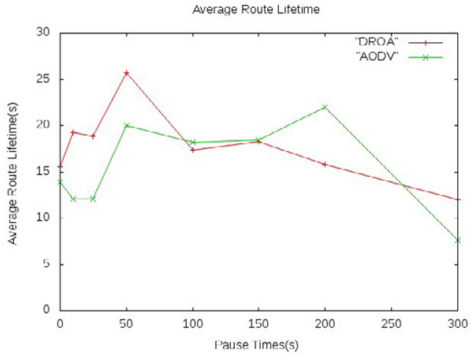

Figure8.Average Route Lifetime

4.Conclusion

In this paper, we have proposed and evaluated an improved dynamic routing optimization algorithm DROA for mobile Ad hoc networks. The proposed algorithm performs probabilistic optimization mechanism, which make use of the broadcast nature of wireless communications to find the shortest route and shrink the path length when the topology changes. DROA can quickly find the nearest downstream node on the route to the destination, or the optimal route which is not on the active route but connect to the destination node. DROA is easy to implement. Experimental results show that the algorithm is well suited for mobile Ad hoc network of high mobility; it can quickly shrink routing, reduce delay and improve the transmission efficiency.

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